

In the Specification:

Please amend the following paragraphs:

[0004] As illustrated, a turbine c is arranged in an exhaust passage b of a diesel engine a, and a compressor e driven by the turbine c is arranged in an intake passage d. An EGR passage f is connected to the exhaust passage b upstream of the turbine c and the intake passage d downstream of the compressor e, so that some of the exhaust gas in the exhaust passage b flows back to the intake passage d through the EGR passage f.

[0007] Conventionally, it is common that EGR is performed only in a low load region and is not performed in a high load region with the EGR valve g closed. The ~~[[Reason]]~~ reason for this is described below. In the low load region, even if the EGR gas is inhaled by the engine, smoke and fuel consumption ~~[[do not aggravate]]~~ are not worsened and power output does not become lower, and the NOx reduction effect as an inherent effect of EGR can be acquired, because an amount of air inhaled by the engine is sufficient to an amount of injection fuel. However, in the higher load region, if the EGR gas is inhaled, the fuel consumption ~~[[aggravates]]~~ is worsened and the power output becomes lower and the smoke tends to be generated, because margin of the amount of intake air relative to the amount of the injection fuel becomes less in the higher load region and an amount of air (oxygen) becomes relatively insufficient.

[0011] According to one aspect of the present invention, there is provided a turbo-charged engine with EGR comprising a turbocharger having a turbine and a compressor, an EGR passage connecting an exhaust passage upstream of the turbine of the turbocharger and an intake passage downstream of the compressor to each other for returning some of exhaust gas in the exhaust passage to the intake passage, and an EGR valve provided in the EGR passage for adjusting a passage area of the EGR passage, wherein capacity of the turbine is set such that in a high speed and high load region of the engine operating state, if the exhaust gas is supplied to the turbine with the EGR valve closed, the turbocharger overruns beyond a maximum speed limit, and if the EGR valve is opened to

return [[the]] some of the exhaust gas to an intake passage side, the turbocharger rotates at less speed than the maximum speed limit.

[0020] Optionally, the engine is a multi-cylinder engine and has an exhaust manifold and an intake manifold at least one of which is divided into two or more, wherein each parts of the divided exhaust manifold or intake manifold are individually connected to the divided or not divided intake manifold or exhaust manifold by two or more of the EGR [[passage]] passages such that when one cylinder involved in the exhaust manifold to which a certain EGR passage is connected is in exhaust stroke, another cylinder involved in the intake manifold to which the certain EGR passage is connected is in intake stroke.

[0021] Optionally, the engine is a multi-cylinder engine and has an exhaust manifold divided into two or more, wherein each parts of the divided exhaust manifold are individually connected to the intake passage by two or more of the EGR [[passage]] passages.

[0022] Optionally, the engine is a [[6-cylinders]] six-cylinder engine and has an exhaust manifold, combustion order of each cylinders is No.1, No.5, No.3, No.6, No.2 and No.4, the exhaust manifold is divided into a first exhaust manifold gathering No.1-3 cylinders and a second exhaust manifold gathering No.4-6 cylinders, and the EGR passage comprises a first EGR passage connecting the first exhaust manifold and the intake passage to each other and a second EGR passage connecting the second exhaust manifold and the intake passage to each other.

[0030] As shown in Fig.1, an in-line [[6 cylinders]] six-cylinder diesel engine 2 is used for a turbo-charged engine 1 with EGR relating to this embodiment. The engine 2 has two turbochargers 5 and 6 (simply referred as "turbo" henceforth) arranged in series in an intake passage 3 and an exhaust passage 4 of the engine 2. That is, a high stage turbine HT and a low stage turbine LT are arranged in the exhaust passage 4 of the in-line [[6 cylinders]] six-cylinder diesel engine 2 at an interval in a direction of exhaust gas flow. A high stage compressor HC and a

low stage compressor LC are arranged in series in the intake passage 3 of the engine 2 at an interval in a direction of intake air flow.

[0032] An exhaust manifold 10 of the engine 2 is divided into a first exhaust manifold 10a gathering Nos.1 to 3 cylinders and a second exhaust manifold 10b gathering Nos.4 to 6 cylinders. An intake manifold 8 is not divided, gathering Nos.1 to 6 cylinders. Combustion order of each cylinder in the in-line six-cylinder engine 2 is generally an order of No.1, No.5, No.3, No.6, No.2 and No.4. Therefore, in one group of cylinders connected to the first exhaust manifold 10a and another group of cylinders connected to the second exhaust manifold 10b respectively, one cylinder is not successively in combustion stroke after another cylinder is in combustion stroke, even in the case that the one cylinder adjoins the another cylinder.

[0035] Check valves 13a and 13b are respectively interposed in the 1st and 2nd EGR passages 11a and 11b to allow the flow only in a direction from the exhaust manifold 10a, 10b to the intake passage 3, and to prevent it from flowing in an opposite direction. For example, a reed valve is used as the check valve 13a and 13b. EGR gas coolers 14a and 14b are interposed in the 1st and 2nd EGR passages 11a and 11b respectively for cooling the EGR gas which flows in the passages. EGR valves 15a and 15b are interposed in the 1st and 2nd EGR passages 11a and 11b respectively for continuously or gradually adjusting flow rate of the EGR gas which flows in the passage from 0% to 100%.

[0038] As is generally known, if capacities of turbines HT and LT are made less, turbos 5 and 6 become easy to rotate. Therefore, in the case that equal flow rate of the exhaust gas to that in the case where the capacity is not made less is supplied to the turbines HT and LT, as shown in Fig.2, if pressure ratio increases with increase of flow rate along an engine operation line Z, the pressure ratio reaches at a point X which is beyond a maximum speed limit line 16. This will probably result in damage of the turbos 5 and 6 due to its overrun. In this embodiment, therefore, capacities of the high stage turbine HT and the low stage turbine LT are set to be less amount such that in the high speed and high load

region of the engine operating state, if the exhaust gas is supplied to the high stage turbine HT with the EGR valve 15a and 15b closed, at least one of the high stage turbine HT and the low stage turbine LT overruns beyond the maximum speed limit line 16 (point X), and if the EGR valve 15a, 15b is opened to return some of the exhaust gas to an intake side, both of the turbines HT, LT operate within the maximum speed limit line 16 (point Y).

[0041] Opening degrees of the EGR valves 15a and 15b are controlled by the control device not illustrated. The control device opens the EGR valves 15a and 15b in a region (crossing region) in which the turbo 5 or 6 exceeds maximum speed limit (limit line 16 shown in Fig.2), according to a map or formula predetermined by experiment, simulation, etc. Thereby, it is avoided beforehand that the turbo 5 or 6 is operated in an overrun region (point X) outside the limit line 16. The turbo 5 or 6 is always operated in a region (point Y) within the limit line 16.

[0045] Described in detail, conventionally, the capacities of the turbos of each [[stages]] stage are set on a premise that EGR is not performed in a high load region of the engine operating state [[at least]] (at least). Therefore, if some of the exhaust gas is fed back to the intake passage side to reduce the flow rate of the exhaust gas supplied to the turbines HT and LT, the capacities of the turbos (or turbines) of each stages do not match with the flow rate supplied to the turbines (i.e., capacities of the turbines of each stages are too much relative to the flow rate of the exhaust gas supplied). This will [[causes]] cause reducing revolution speed of the turbos. Accordingly, intake pressure becomes insufficient and power output declines. Furthermore, turbo efficiency becomes lower and fuel consumption also gets worse since the turbos operate in a region not matching up with the capacity of turbines HT, LT. In addition, generally, EGR is prohibited with the EGR valves closed in the high load region where high power output is necessary, since the amount of air is insufficient to the amount of injection fuel and smoke tends to generate in the high load region.

[0050] Since the check valves 13a and 13b are respectively interposed in the EGR passages 11a and 11b, adverse current of the intake air from the intake passage 3 side to the exhaust manifold 10 side can be securely prevented. If a reed valve etc. is used for the check valves 13a and 13b, the check valves 13a and 13b can open and close appropriately at quite short [[cycle]] cycles in response to exhaust pulsation and intake pulsation. Even if average exhaust gas pressure and average intake pressure are nearly equal to each other, the check valves 13a and 13b can open immediately when instantaneous exhaust gas pressure exceeds instantaneous intake air pressure in intake and exhaust pulsation process. This realizes appropriate EGR to be performed.

[0051] In this embodiment, the exhaust manifold 10 of the in-line, [[6 cylinders]] six-cylinder engine 2 is divided into the first exhaust manifold 10a gathering Nos.1-3 cylinders and the second exhaust manifold 10b gathering Nos.4-6 cylinders, and the EGR passages 11a, 11b are respectively connected to the first and second exhaust manifold 10a, 10b, and the check valves 13a, 13b are respectively provided in each of the EGR passages 11a, 11b. Accordingly, pressure in intake stroke can be higher than average pressure, and pressure in exhaust stroke can be lower than average pressure.

[0052] That is, in the case of the in-line [[6 cylinders]] six-cylinder engine 2, when No.1 cylinder is in intake stroke, No.3 cylinder is in exhaust stroke. When the No.3 cylinder starts to exhaust, exhaust gas pressure momentarily becomes high which opens the check valve 13a (reed valve) to make the EGR gas to flow. No.1 cylinder is in intake stroke at this time, which means that intake pressure into No.1 cylinder increases by introduction of the EGR gas with high pressure from No.3 cylinder. On the other hand, seeing from No.3 cylinder, exhaust gas pressure of the No.3 cylinder decreases as the No.1 cylinder positively sucks the exhaust gas from the No.3 cylinder. The same things happen in all cylinders. For this reason, pumping loss decreases, and pumping gain increases which is advantageous for fuel consumption.